Flood Hazard Mapping Using Geographic Information Systems (GIS) in the Walanae River Basin Wajo Regency of South Sulawesi Province

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Flood Hazard Mapping Using Geographic Information Systems (GIS) in the Walanae River Basin Wajo Regency of South Sulawesi Province

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Key words: GIS, map, ArcGIS 10.1, flood volume, topographyic data, Pammaua district

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Abstract: Mapping flood-prone areas is one way to control floods in a non-structural way. The area around the Walanae river in Wajo district experiences flood every year and gets the biggest impact from the flood event. This study aims to map flood-prone areas and flood risks according to the area that gets the greatest impact. Analysis of flood-prone areas in this study uses the application of Geographic Information Systems (GIS) with three parameters, namely topographic data, flood volume DEM. The analysis was performed using the scoring and weighting methods. Geographic Information System is used as a spatial model in mapping flood potential using the overlay/intersect technique in ArcGIS10.1 and represent it in the form of a map based on the three parameters used. In this study, a high hazard class value of 8.21% was obtained for Pammana district, 7.49% for Sabbang Paru district and 7.68% for Tempe district.

INTRODUCTION

Floods usually occur in areas that have lower topography (basins) with high levels of regional rainfall[1, 2]. In addition, the occurrence of flooding can be caused by overflow of runoff and the volume exceeds the capacity of the drainage system or river flow system[3]. According to Marchi *et al.*[4], typical land characteristics that have the potential to experience flooding can provide information about a flood hazard condition related to geomorphological and hydrological characteristics in the area (i.e., frequency, area and length of inundation, maybe even the source of the cause). Thus, it can be assumed that geomorphological and hydrological surveys on alluvial plains, flood plains and other lowlands can be used to estimate the historical development of the area in relation to flood events[5].

Making maps to determine flood risk areas based on Geographic Information Systems[6-8] is needed as a step in reducing the impact caused by floods[9]. To compile a flood hazard and inundation maps, it is necessary to quantify the amount of flood and inundation which covers the area and also height and duration of inundation which are represented in the form of maps[10-12]. This mapping of flood and inundation-prone areas would be better if it could be overlaid with river hydrological networks maps and topographic maps because areas that have the potential to experience subsequent inundation if river discharge or rainfall continues to increase can be monitored[5, 6, 13] and DEM data[14, 15].

Data from the National Disaster Management Agency (BNPB, 2012) shows that the Wajo regency in the area around the Walanae river is an area that has the highest risk of flooding compared to other districts in South Sulawesi province. In 2019, there was a flood that caused huge losses and casualties in the area. The purpose of this study is to analyze flood-prone areas in the Walanae river basin of Wajo regency using Geographic Information Systems (GIS) with ArcGIS 10.1 Software.

MATERIALS AND METHODS

Research object: Geographically, the Walanae River area of Wajo Regency is located between 119°05’00”-120° 00’05” East Longitude (EL) and between 4°54’36”-5° 8’19” South Latitude (SL). Located in three districts namely Pammana district, Sabbang Paru district and Tempe district. The research object is shown in Fig. 1.

Research data sources: Data is taken from the results of measurements made in the field then the data processing is done to illustrate the map of flooded areas in the field. The area of observation is presented in Fig. 2.

Data processing from topographic base maps is done using the DEM method[14] and land use maps are obtained from digital maps of RBI with a scale of 1: 50,000 and the magnitude of flood volumes known[15]. Attribute analysis using the scoring or weighting method is applied to the data that has been collected. Spatial analysis conducted at the data analysis stage is overlaid on all thematic maps that are flood parameters. The result of the overlay technique is new information in the form of an area or polygon.

The level of flood risk is categorized based on the depth of the flood water. Flood water level between 0-100 cm is low hazard class, flood water level between 100-200 cm is medium hazard class and water level >200 cm is high hazard class. For the value of losses for those affected based on the weighting results with the AHP method[16] are settlements have a value of 0.18, offices is 0.15, educational facilities is 0.14, road facilities is 0.14, paddy fields have a value of 0.11, mixed gardens is 0.08 and fish ponds/ponds worth 0.06 while the use of open space/fields, shrubs, mangroves and rivers are not taken into account.

Fig. 1: Research location

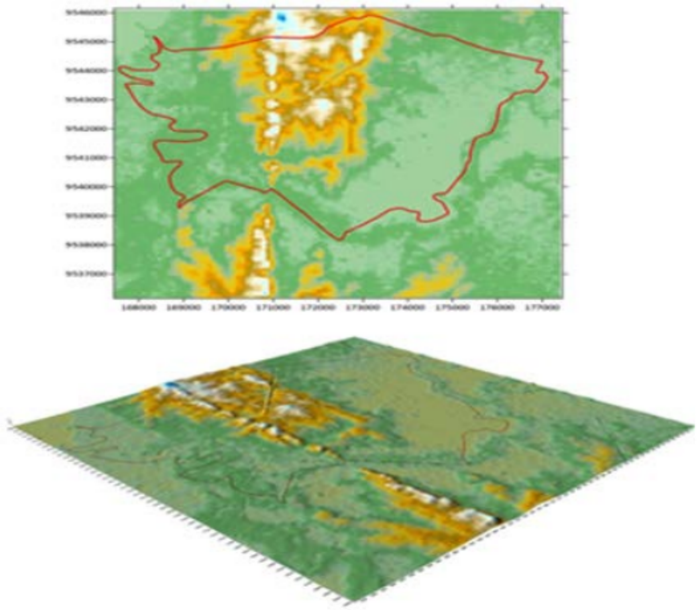

Fig. 2: Coverage area of resaerch observation in Wajo regency

Each parameter is weighted based on the amount of risk arising from the spatial flood event. To give weight to several parameters, the value of the interval class must be known. The equation used to create interval classes is the Sturgess equation by Andriyani:

$$Ki = (Xt\text{-}Xr)/k$$

Where:
Ki = Interval class
Xt = The highest value
Xr = The lowest value
k = Number of classes

The level of flood hazard indicates the level of threat in an area where there are community activities that can result in a loss between the Hazard component (H) and Vulnerability (V). The overlay process for all flood risk parameters uses the following equation:

$$Risk = (Hazards \times Vulnerability)/capacity$$

The level of risk is assessed spatially to produce a risk map. The weight of each component is 0.5. scores for each component class (hazard and vulnerability) are 0.33 (low), 0.67 (moderate) and 1 (high). Risk classes are classified by the equal interval method into three classes, namely low, medium and high.

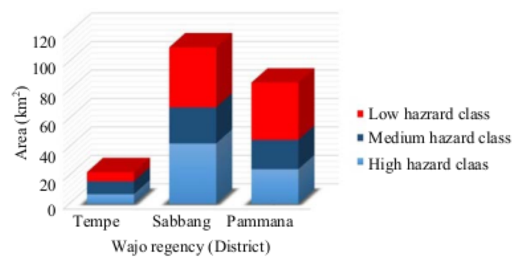

Fig. 3: The area of each flood hazard class based on village administration map in Wajo regency

RESULTS AND DISCUSSION

At Wajo regency in Walanae river region, the largest flood event ever occurred between a depth 1.5-3-5 and an inundation area of 21.698 ha (Fig. 3). Flood locations are spread across three districts including district of Tempe, Sabbang Paru and Pammana. As it is known that these areas are traversed by Walanae river. The results can be seen in Fig. 3. The impact of flood losses is presented in Table 1 and the area of the flood that affected by flood hazard class is presented in Fig. 4.

Furthermore, a flood hazard map is made which is the result of an overlay between a map of the earth and a map of the satellite imagery shown in Fig. 5 as well as a map of the topographic measurements as shown in Fig. 6.

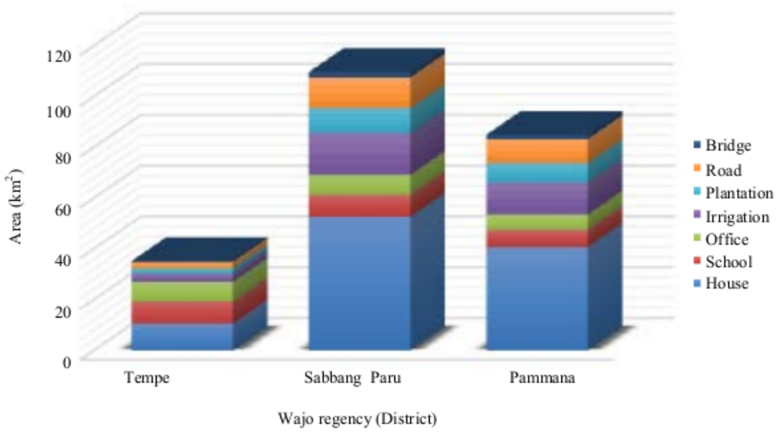

Fig. 4: The area of each flood hazard class based on infrastructure and facilities affected by the flood

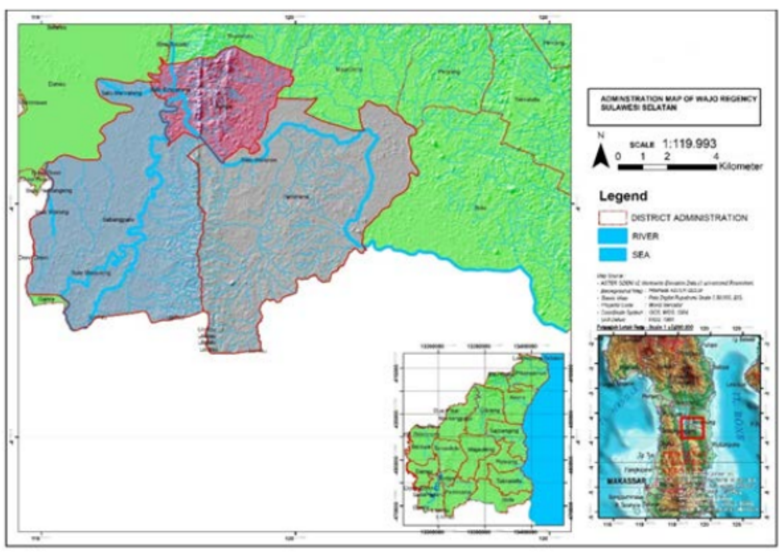

Fig. 5: Administrative map for Walanae river, Wajo regency

Table 1: The impact of flood losses

	Area (km^2) (District)		
Variables	Tempe	Sabbang Paru	Pammana
House	10.63	52.70	40.82
School	8.78	8.78	6.80
Office	7.69	7.69	5.95
Irrigation	3.32	16.47	12.76
Plantation	1.99	9.88	7.65
Road	2.44	12.08	9.36
Bridge	0.44	2.20	1.70

With reference to the highest flood events that have ever occurred from surveys and inventories an analysis of flood events for the affected area and from the affected facilities and infrastructure resulted in a flood hazard map shown in Fig. 7.

For Tempe district there are 10 affected villagesnamely, Tempe village, Watallipue, Teddaopu, Lapongkoda, Padduppa, Manddukelleng, Sitampae, Wiringpolennae, Siengkangand Salomenraleng. Administratively, the high hazard class dominates in Tempedistrict, namely in the village of Tempe (1.700 ha or 7.68% of total area of hazard area), Watalippue (1.100 ha or 4.497%), Teddaopu (82 ha or 3.97%) and Salomenrang (285 ha or 12.78%).

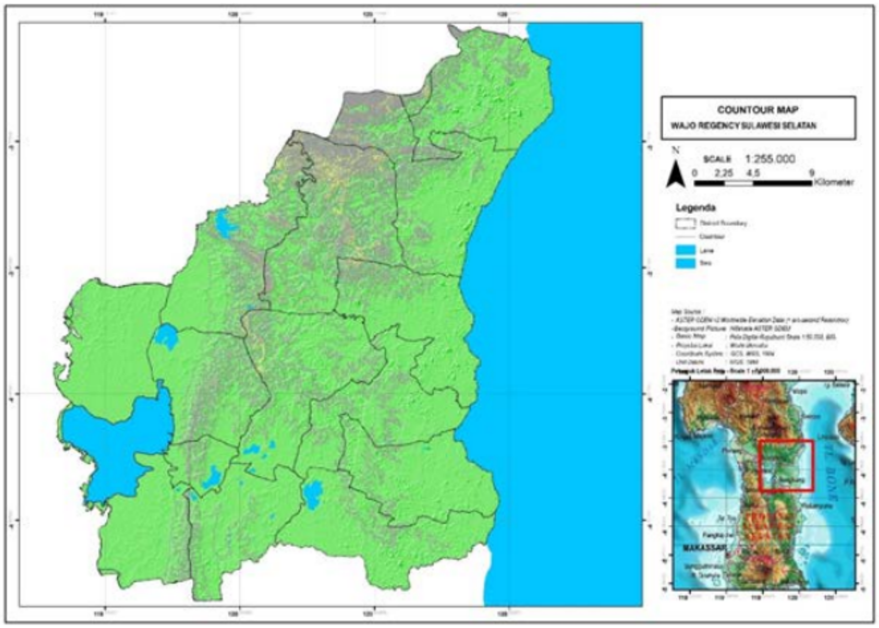

Fig. 6: Contour map of Wajo regency

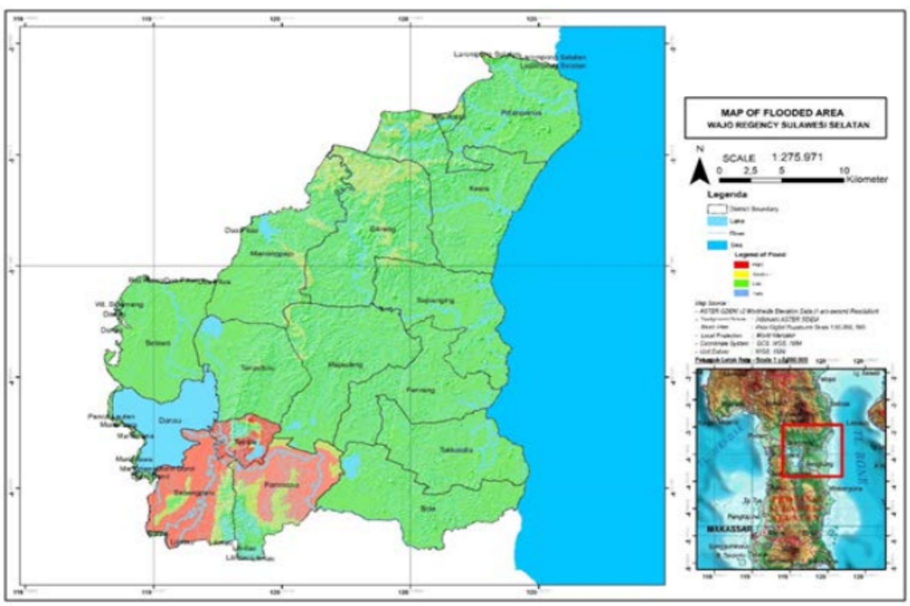

Fig. 7: Map of the flooded area in Wajo regency

Moderate class is in village of Lapongkoda (91 ha or 4.11% of total area of hazard area), paduppa (160 ha or 7023%), Mandudukelleng (418 ha or 18.88%) and Sitampae (233 ha or 12.87%). Low class dominates in these regions, namely Village Wiringpolennae and salomenrang with total 511 ha and 154 ha respectively. As it is shown on Fig. 8 for Prone-flood map and facilities and infrastructures affected as shown on Fig. 9.

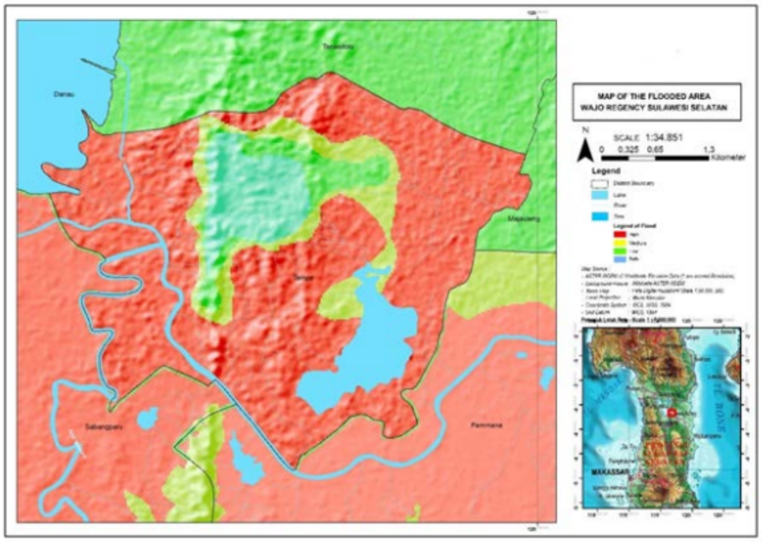

Fig. 8: Map of the flooded area of Tempe district in Wajo regency

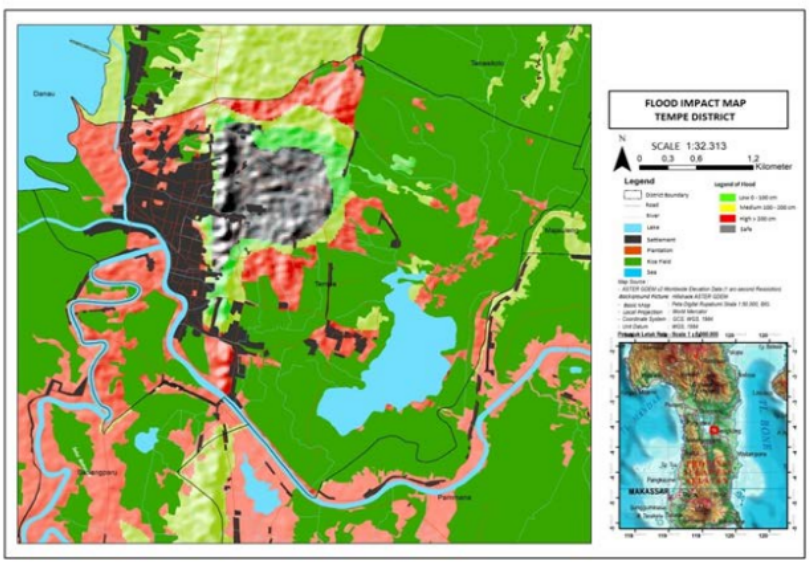

Fig. 9: Flood impact map of Tempe district

For Sabbang Paru district, there are 13 affected villages, namely Benteng Lompoe village, Ujung Pero, Mallusesalo, Wage, Sompe, Salotengnga, Walanae, Liu, Tanddangpalie, Ugi, Bila, Pasaka and Worongnge. In Sabbang Paru district, high hazard class is spread across Village Benteng Lompoe (822 ha or 7.49%). Ujung Pero (954 ha or 8.69%), Mallusesalo (477 ha or 4.34%), Wage (801 ha or 7.30%), Sompe (1160 ha or 10.57%). Moderate class is village Salotengnga (446 ha or 4.06%). Walanae (584 ha or 5.32%) and Liu (584 Ha or 5.32%) and Palangiseng (1400 ha or 4.06%).

Low class is Village Macanre (400 ha or 2.14%), Pajalesang (1200 ha or 6.42%) and Paroto (1700 ha or 9.09%). It is shown in Fig. 10 for prone-flood mapand facilities and infrastructures affected as shown on Fig. 11.

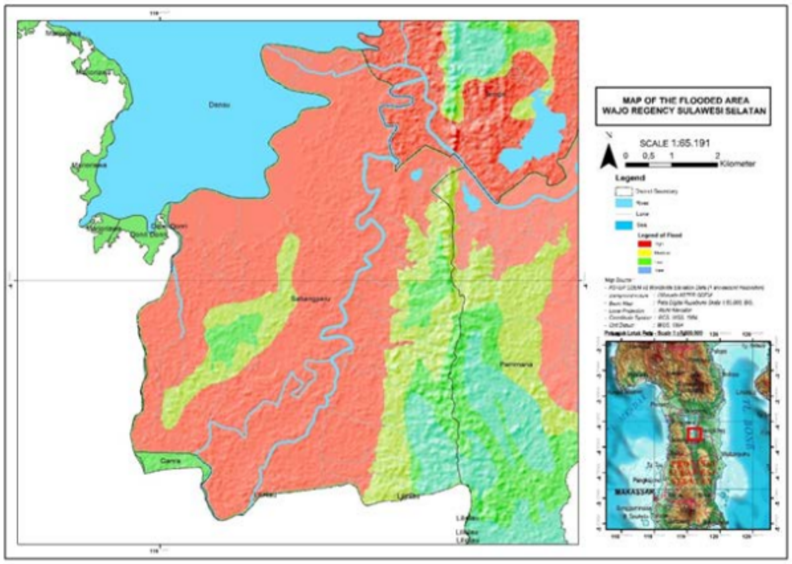

Fig. 10: Map of the flooded area of Sabbang Paru district in Wajo regency

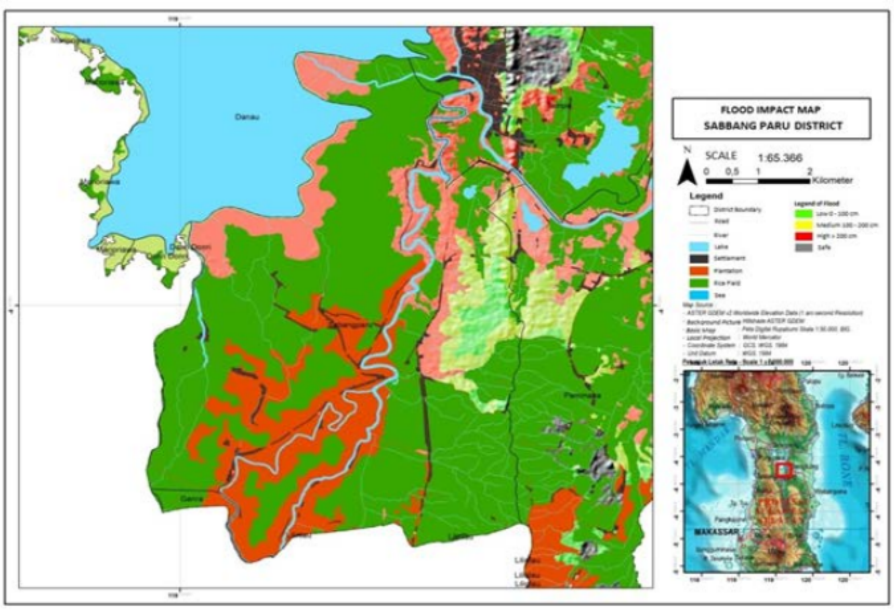

Fig. 11: Flood impact map of Sabbang Paru district

For Pammana district, there are 8 affected villages namely: Lempa village, Lagosi, Lapaukke, Abbanuangnge, China, Tadang Pale, Watampanre and dan Pallawurka. For Pammana district, the high hazard is spread ini Lempa village (698 ha or 8.21%), Lagosi (1.497 ha or 17.60%), Lapaukke (1.230 ha or 14.46%) and Abbanuangnge (600 ha or 7.05%). Moderate class is Tadang Pale village (1.271 ha or 14.94%) amd Watampanre (786 ha or 9.24%). Low class is China village (1.663 ha or 19.55%) and Pallawarukka (760 ha

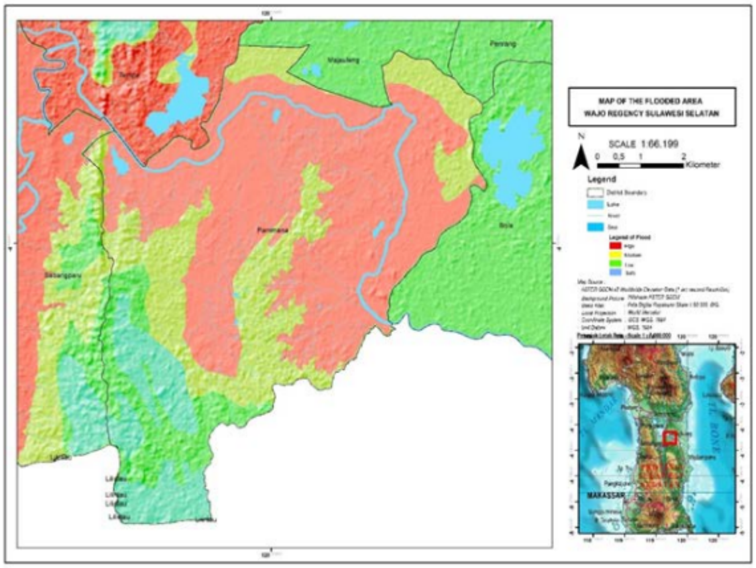

Fig. 12: Map of the flooded area of Pammana district in Wajo regency

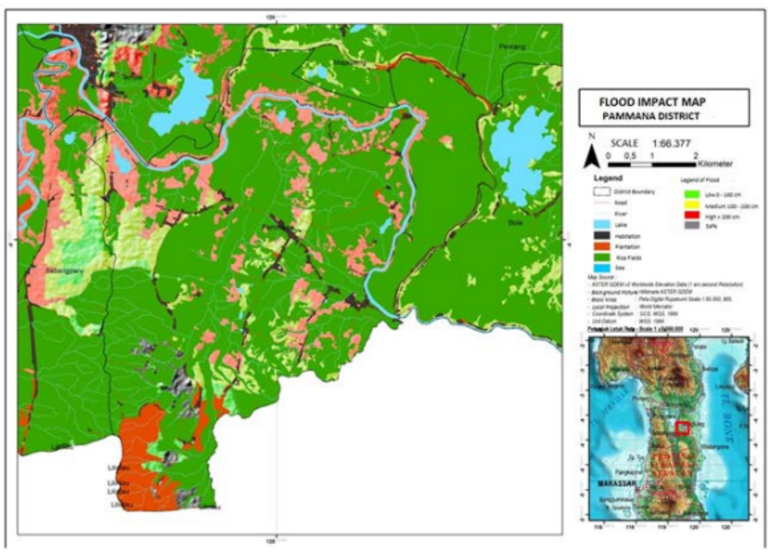

Fig. 13: Flood impact map in Pammana district

or 8.94%). It is shown on Fig. 12 for prone-flood map and facilities and infrastructures affected as shown in Fig. 13 in Pammana district.

CONCLUSION

Based on the results obtained from this study, it can be concluded that Wajo regency in Walana river region has three levels of flood hazard namely, the hight hazard class, moderate class and low class which are spread across three districts namely; Tempe, Sabbang Paru and Pammana. The largest flood event ever occurred between a depth 1.5-3.5 m and an inundation area of 216.98 km^2. Total area for the high hazard class in Pammana district is 40.25 km^2, Sabbang Paru is 42.14 Km^2 and Tempe is 6.47 km^2.

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